

Bulletin of Monetary Economics and Banking, Vol. 22, No. 4 (2019), pp. 405 - 422

p-ISSN: 1410 8046, e-ISSN: 2460 9196

UNDERSTANDING INDONESIA'S CITY-LEVEL CONSUMER PRICE FORMATION: IMPLICATIONS FOR PRICE STABILITY

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ABSTRACT

Using the Consumer Price Index (CPI) data of 82 Indonesian cities, we propose the hypothesis of heterogeneity in the cities' contribution to the aggregate Indonesian CPI. Using a price discovery model fitted to monthly data, we discover that (1) of the 23 cities in the province of Sumatera, five contribute 44% and nine contribute 66.7% to price changes, and (2) of the 26 cities in Java, four alone contribute 41.6% to price changes. Even in smaller provinces, such as Bali and Nusa Tenggara, one city alone dominates the change in aggregate CPI. From these results, we draw implications for maintaining price stability.

Keywords: Consumer Price Index; Cities; Price discovery; Bank Indonesia.

JEL Classifications: E31; E37.

Article history:

Received : August 10, 2019

Revised : November 12, 2019

Accepted : November 30, 2019

Available online : December 31, 2019

<https://doi.org/10.21098/bemp.v22i4.1239>

I. INTRODUCTION

Inflation is an important subject that dictates policymaking. Both monetary and fiscal policies are inflation dependent. Therefore, an understanding of the determinants of inflation and its relations with other macroeconomic variables has formed the basis for multiple theories and hypotheses in economics, including those of Alba and Papell (1998), Hendry (2001), Ciccarelli and Mojon (2010), Narayan, Narayan, and Mishra (2011), and Sharma (2019). In this paper, we do not engage in either of these areas of analysis; rather, we propose a question that has not been previously addressed by the literature: among multiple cities, which city (or group of cities) dominates the formation of Consumer Price Index (CPI) inflation? The intuition is the following. In a large region/province/state, there are multiple cities. Given many cities, we argue—and it is natural, too—that some cities will be price takers and some price setters. This will result from the fact that some cities are small while others are large. Size dictates the level of economic activity, which, in turn, influences price changes and their evolution. In such a situation, the question is not only which city contributes most to price changes, but how much, precisely, do they contribute to price changes?

This paper addresses these two questions using quarterly CPI data for 82 cities from Indonesia's six provinces. We employ a recent price discovery methodology proposed by Westerlund, Reese, and Narayan (2017; WRN hereafter). This method has several advantages. The one that motivates our hypothesis proposal and test is that, unlike other econometric methods (e.g., a vector autoregressive or vector error correction model), WRN's method does not restrict the number of price variables that can be simultaneously modeled. This ensures that we can avoid the price variable selection bias that characterizes many empirical papers on price discovery.

Our empirical analysis leads to the following conclusions. Of Sumatera's 23 cities, nine alone contribute 66.7% to price changes and five contribute 44%. Similarly, of the 26 cities in Java, nine contribute 65% to all price changes, with four contributing 41.6%. Even in smaller provinces, such as Bali and Nusa Tenggara, where there are only five cities, one city alone contributes around 43% to all price changes. Across all six provinces, we identify leader cities (that is, those cities that drive the bulk of the price changes). The implication of our results is that each province in Indonesia has between six and 26 cities, for a total of 82 cities. In controlling prices, given that the objective of Bank Indonesia, the central bank, is to maintain price stability, pricing-related policy should pay more attention to the cities we identify as leaders in moving aggregate (national) CPI.

Our contributions to the literature are threefold. First, our proposal, a hypothesis that aims to test the heterogeneity in the cities' contribution to the aggregate CPI (which in other words identifies leader cities') is original. This type of analysis on a search for leading cities (or a leader city) in price changes (from an inflation perspective) has not been previously considered. Our idea can therefore be tested in other countries to see if groups of cities can be identified that drive price changes. This information is important for price stability-based policies in countries and/or regions with many cities. In this regard, the novelty of our research question and approach contributes broadly to the literature on the evolution of price changes; see, for instance, Zozicki and Tinsley (2012) and Kilian (2008).

Second, our work is connected to the literature (see, *inter alia*, Basher and Westerlund, 2008; Culver and Papell, 1997; Westelius, 2005) that tests for persistency of inflation. The idea inherent in this literature is policy based, in that, if shocks to inflation are temporary (short term), then the persistency test (typically conducted using unit root tests) will imply a stationary inflation rate. By comparison, if the inflation rate appears to be nonstationary, then shocks are likely to have a long-term effect. Finding evidence of temporary or long-term effects of shocks on inflation has implications for price stability, particularly about policies that can support price stability. The unit root literature's limitation in informing policy in this way is that it considers one city (or country) at a time; that is, the cities or countries are not all modeled simultaneously. This is wasteful, because there is a loss of information from cities ignored by the analysis. Therefore, one could argue that a unit root test is always associated with a model misspecification problem when the hypothesis test is of the type we examine in this paper. This is not to say that unit root tests should not be used. They are powerful tools which should be employed by researchers; however, our argument is that when one wants to search for leader cities amongst a large group of cities, the unit root test is unlikely to be the most suitable tool. It follows that the type of price discovery model we employ circumvents this model misspecification concern by considering all cities in a single model. We argue that, by employing the WRN framework, we have a relatively complete model for understanding the joint (among cities, as in our example) evolution of prices.

Our final contribution is to the Indonesia-specific literature on inflation. In a recent paper that inspired our proposed hypothesis test, Jangam and Akram (2019) show that city-level prices in Indonesia weakly converge. Their analysis points to four convergence clubs among a large group of Indonesian cities. Their policy recommendation is rather complex, because they suggest targeting those four groups of cities to achieve price convergence. Our results support theirs, in that the bulk of Indonesian cities do not contribute to price changes in a statistically significant manner. Where we differ, however, is in our identification of leader cities. A key advantage of our approach and finding is the recommendation to target those cities that are price drivers (or leaders). Our policy recommendation is thus less complex, tractable, and easy to implement.

The remainder of the paper is organized as follows. Section II explains the methodology. Section III describes the data and the results. Section IV highlights our key findings and implications.

II. METHODOLOGY

To test our hypothesis that certain cities in Indonesia contribute more to the Consumer Price Index (CPI) than others, we employ the discovery model of WRN. WRN's model is a common factor model, of the following form:

$$P_{i,t} = \alpha_i CF_t + Z_{i,t} \quad (1)$$

where $CPI_{i,t}$ is the CPI of city i , $i=1, \dots, 82$, in period $t=2014M01, \dots, 2018M04$, where M01 denotes the month of January and M04 the month of April. The monthly data frequency ensures that each city has 52 data points.

The common factor, CF_t , is the aggregate (country) Indonesian CPI. The construction of Equation (1) implies that the common factor (the CPI of Indonesia) is thus applicable (or is common) to each Indonesian city. Each city's relation to the common factor is represented by α_i . Finally, $Z_{i,t}$ is an idiosyncratic error term. According to price discovery theory, the fundamental price (CF_t) should follow a random walk and be common across cities, while the noise component ($Z_{i,t}$) should be stationary and idiosyncratic. It therefore follows that $\alpha_1 = \dots = \alpha_{82} = 1$. The idea behind Equation (1) is to discover (hence the term *price discovery*) which city contributes, and how much, to the movement of the aggregate CPI.

To extract the share (or contribution) of each city's CPI to the aggregate CPI, we employ Hasbrouck's (1995) information share (*Contribution*), which has been extended by WRN to a panel version (to accommodate the panel of 82 cities in our example) in the spirit of Narayan, Sharma, and Thuraisamy (2014) as follows:

$$Contribution_i = \frac{\alpha_i^2 \sigma_{cf}^2 \sigma_{Z,i}^{-2}}{\sum_{n=1}^{82} \alpha_n^2 \sigma_{cf}^2 \sigma_{Z,n}^{-2}} \quad (2)$$

where $\sigma_{Z,i}^2$ is the variance of $Z_{i,t}$ and σ_{cf}^2 is the variance of $cf_i = CF_t - CF_{t-1}$, the shock to the fundamental price. This equation states that (a) the lower the amount of noise (σ_Z^2) in the CPI of city i , the higher that city's contribution to the aggregate CPI, and (b) as the covariance between the CPI of city i and the aggregate CPI (α_i) increases, that city's contribution to the aggregate CPI rises. Further details on the methodology are provided by Narayan, Phan, Thuraisamy, and Westerlund (2016) and Narayan, Sharma, Thuraisamy, and Westerlund (2018). We refer readers to these papers.

III. DATA AND RESULTS

The data for this paper are taken from an earlier paper published in this journal (Jangam and Akram, 2019). The data set is monthly and spans the period from January (M01) 2014 to April (M04) 2018. It should be noted that, while Jangam and Akram (2019) use data up to August 2019, we had to truncate the sample to a common end date to remain consistent with the econometric methodology. Further details on the data are given by Jangam and Akram (2019).

Before we examine our main hypothesis, a descriptive story of the data set is in order. Table 1 reports common descriptive statistics organized by city and categorized into the six provinces. A key feature of the data is that not only do the mean and the variance of *CPI* inflation vary by city and by province, but also, as noted in the last column, the sample growth rate and average annual growth rate of the *CPI* vary vastly both among cities in a province and across provinces. Some discussion on this is warranted. In Sumatera, for instance, the annual average price growth is recorded at 4.64%, with 13 of 23 cities experiencing annual price growth in excess of 4.64%. Java has an annual average price growth rate of 4.27%, with 13 of 26 cities experiencing a rate in excess of 4.27%. In other, smaller provinces, the story is similar: in Bali, Kalimantan, and Sulawesi, three of six, five of nine, and

six of 11 cities, respectively, have growth rates in excess of their province's annual average growth rate. When comparing *CPI* growth rates across cities, we also see differences: Maluku-Papua has the highest annual average price growth rate (5%), followed by Kalimantan (4.94%), Sumatera (4.64%), Sulawesi (4.54%), Java (4.27%), and Bali (4.21%). There is almost a 20% difference in price growth between the high-price growth rate provinces (e.g., Maluku-Papua and Kalimantan) and the low-price growth rate provinces (e.g., Java and Bali).¹

Table 1.
Descriptive Statistics

This table reports some commonly used descriptive statistics (mean, standard deviation, skewness and kurtosis) of each city's *CPI* return. The final two columns report the average annual growth rate and full sample growth rate of each city's *CPI*.

Region	City	CPI returns				CPI	
		Mean	S.D.	Skewness	Kurtosis	Average annual growth rate	Full sample growth rate
Sumatera	Meulaboh	0.310	0.697	0.834	5.432	3.746	17.465
	Banda Aceh	0.306	0.635	0.469	3.592	3.843	17.249
	Lhokseumawe	0.346	0.859	-0.005	3.669	4.353	19.697
	Sibolga	0.431	1.132	-0.384	3.383	5.481	25.102
	Pematang Siantar	0.372	0.710	0.563	4.481	4.817	21.327
	Medan	0.405	0.723	-0.160	3.723	5.319	23.453
	Padang Sidempuan	0.336	0.712	0.217	3.478	4.238	19.105
	Padang	0.379	0.935	0.372	5.192	4.798	21.815
	Bukit Tinggi	0.341	0.825	-0.421	4.437	4.077	19.396
	Tembilahan	0.389	0.633	1.160	5.255	4.015	22.410
	Pekanbaru	0.385	0.602	0.116	4.027	4.859	22.195
	Dumai	0.379	0.506	0.623	4.013	4.891	21.815
	Bungo	0.341	0.707	0.461	3.544	4.316	19.407
	Jambi	0.341	0.836	-0.059	3.657	4.087	19.382
	Palembang	0.359	0.613	1.191	6.756	4.669	20.552
	Lubuk Linggau	0.391	0.762	0.765	4.680	4.976	22.569
	Bengkulu	0.446	0.838	0.916	4.696	5.803	26.104
	Bandar Lampung	0.384	0.578	1.049	6.303	4.963	22.074
	Metro	0.285	1.713	-1.037	19.759	3.758	15.971
	Tanjung Pandan	0.418	1.248	0.183	2.820	4.945	24.304
	Pangkal Pinang	0.442	1.193	0.310	3.150	5.754	25.822
Bali	Batam	0.392	0.677	0.667	4.156	5.182	22.641
	Tanjung Pinang	0.308	0.664	0.514	5.798	3.942	17.359

¹ We do not conduct the Narayan and Popp (2010, 2013) endogenous structural break test because it was unlikely to change the hypothesis we are proposing to test. However, we believe that doing a persistency test of *CPI* using the dataset we have here will constitute a separate paper. In such an endeavor, the half-life can be computed to understand the heterogeneity of city-based inflation to shocks.

Table 1.
Descriptive Statistics (Continued)

This table reports some commonly used descriptive statistics (mean, standard deviation, skewness and kurtosis) of each city's *CPI* return. The final two columns report the average annual growth rate and full sample growth rate of each city's *CPI*.

Region	City	CPI returns				CPI	
		Mean	S.D.	Skewness	Kurtosis	Average annual growth rate	Full sample growth rate
Java	Jakarta	0.361	0.480	2.538	12.479	4.452	20.639
	Bogor	0.360	0.483	-0.088	5.881	4.513	20.584
	Sukabumi	0.345	0.479	1.712	8.335	4.172	19.644
	Bandung	0.368	0.459	1.464	7.678	4.480	21.069
	Cirebon	0.303	0.431	0.720	4.003	3.605	17.043
	Bekasi	0.324	0.543	0.856	4.515	3.897	18.321
	Depok	0.316	0.528	0.871	4.845	4.024	17.889
	Tasikmalaya	0.365	0.458	1.620	8.883	4.484	20.893
	Cilacap	0.365	0.534	0.817	2.921	4.433	20.898
	Purwokerto	0.318	0.520	0.612	3.774	3.942	17.958
	Kudus	0.374	0.568	1.041	5.057	4.496	21.489
	Surakarta	0.319	0.545	0.680	5.492	3.812	18.072
	Semarang	0.343	0.518	1.038	6.136	4.166	19.495
	Tegal	0.357	0.499	0.371	2.746	4.512	20.399
	Yogyakarta	0.318	0.416	1.095	4.586	3.946	18.008
	Jember	0.307	0.542	2.089	8.889	3.800	17.330
	Banyuwangi	0.280	0.492	1.412	9.597	3.397	15.654
	Sumenep	0.318	0.513	1.456	8.384	3.995	17.979
	Kediri	0.274	0.526	1.633	8.250	3.403	15.289
	Malang	0.356	0.513	1.912	10.009	4.538	20.310
	Probolinggo	0.269	0.457	1.601	6.908	3.322	15.013
	Madiun	0.343	0.465	1.413	6.819	4.318	19.533
	Surabaya	0.374	0.470	1.650	7.024	4.657	21.460
	Serang	0.432	0.730	-0.751	6.270	5.553	25.168
	Tangerang	0.461	0.901	0.835	8.141	5.452	27.070
	Cilegon	0.439	0.672	0.837	6.422	5.576	25.618
Bali & Nusa Tenggara	Singaraja	0.418	0.763	0.525	3.797	5.130	24.303
	Denpasar	0.353	0.488	1.161	4.659	4.134	20.143
	Mataram	0.331	0.584	0.679	3.999	4.101	18.786
	Bima	0.363	0.718	0.262	2.371	4.255	20.782
	Maumere	0.262	0.614	0.831	4.040	3.354	14.598
	Kupang	0.337	0.906	1.020	4.990	4.306	19.127
Kalimantan	Pontianak	0.459	0.833	0.920	4.000	5.851	26.982
	Singkawang	0.432	0.683	0.624	2.829	5.040	25.170
	Sampit	0.396	0.577	-0.110	3.509	4.857	22.881
	Palangkaraya	0.317	0.552	0.141	2.367	3.934	17.936
	Tanjung	0.406	0.744	0.438	3.267	4.731	23.504
	Banjarmasin	0.379	0.461	0.639	3.037	5.046	21.807

Table 1.
Descriptive Statistics (Continued)

This table reports some commonly used descriptive statistics (mean, standard deviation, skewness and kurtosis) of each city's *CPI* return. The final two columns report the average annual growth rate and full sample growth rate of each city's *CPI*.

Region	City	CPI returns				CPI	
		Mean	S.D.	Skewness	Kurtosis	Average annual growth rate	Full sample growth rate
Sulawesi	Balikpapan	0.396	0.716	0.681	2.773	5.062	22.836
	Samarinda	0.346	0.509	1.691	7.399	4.534	19.725
	Tarakan	0.431	0.678	1.176	4.763	5.419	25.108
	Manado	0.378	0.948	0.940	5.169	4.733	21.729
	Palu	0.372	0.876	0.223	3.616	4.584	21.315
	Bulukumba	0.372	0.674	0.534	4.691	4.269	21.349
	Watampone	0.335	0.643	0.617	4.497	3.981	19.052
	Makassar	0.420	0.580	1.186	5.510	5.371	24.395
	Pare-pare	0.310	0.804	1.373	7.34	4.109	17.487
	Palopo	0.394	0.665	1.288	4.889	4.584	22.726
	Kendari	0.29	0.897	1.415	6.619	4.296	16.291
	Bau-bau	0.364	1.079	0.269	2.897	4.765	20.822
Maluku-Papua	Gorontalo	0.303	0.836	1.641	9.163	4.395	17.083
	Mamuju	0.364	0.608	0.553	4.667	4.827	20.838
	Ambon	0.31	0.891	-0.03	4.394	4.131	17.510
	Tual	0.517	1.509	-0.166	3.045	8.317	30.837
	Ternate	0.374	0.878	0.264	4.209	4.554	21.448
	Manokwari	0.308	0.803	0.050	2.893	4.206	17.341
	Sorong	0.365	0.748	0.382	2.927	4.519	20.891
	Merauke	0.431	1.154	0.40	5.515	4.902	25.154
	Jayapura	0.362	0.996	1.039	5.831	4.405	20.688

When we note the volatility of the inflation rate, as depicted by the standard deviation of the price change, we again see that, within provinces, some cities experience higher volatility in price changes. The results in Table 2 show evidence of serial correlation in price changes and their persistence. We observe that the majority of the cities have price changes that are best characterized as serially correlated, suggesting that current price changes are related to future price changes. Although this is true for most cities, what is different is the magnitude of serial correlation as measured by the first-order autoregressive coefficient reported in the last column. Kalimantan, Java, and Bali, and Nusa Tenggara have a price persistency of 0.22, 0.20, and 0.19, respectively, while, for Java, Sulawesi, and Maluku-Papua, the persistency in prices is much lower, at 0.12, 0.07, and 0.05, respectively.

Table 2.
Persistence of Cities' CPI Returns

This table reports the persistency of CPI returns by way of the estimated first-order autoregressive, or AR(1), coefficient and the Ljung-Box Q-stat for serial correlation at lag 1–12.

Province/ Region	City	Ljung-Box test		AR(1)	
		Q-stat	p-value	Coef.	p-value
Sumatera	Meulaboh	13.545	0.331	0.127	0.321
	Banda Aceh	53.562	0.000	0.196	0.144
	Lhokseumawe	39.303	0.000	0.199	0.140
	Sibolga	29.139	0.004	0.135	0.320
	Pematang Siantar	29.049	0.004	0.031	0.830
	Medan	16.613	0.165	0.257	0.068
	Padang Sidempuan	24.569	0.017	0.065	0.644
	Padang	19.654	0.074	0.304	0.026
	Bukit Tinggi	23.472	0.024	0.178	0.194
	Tembilahan	15.878	0.197	0.011	0.930
	Pekanbaru	10.975	0.531	0.099	0.488
	Dumai	14.992	0.242	0.284	0.044
	Bungo	24.505	0.017	0.306	0.027
	Jambi	29.688	0.003	0.135	0.336
	Palembang	25.416	0.013	0.187	0.183
	Lubuk Linggau	15.579	0.211	0.140	0.319
	Bengkulu	20.129	0.065	0.237	0.093
	Bandar Lampung	12.188	0.431	0.114	0.427
	Metro	23.688	0.022	-0.602	0.000
	Tanjung Pandan	38.956	0.000	0.219	0.099
	Pangkal Pinang	23.991	0.020	-0.107	0.418
	Batam	28.299	0.005	0.175	0.223
	Tanjung Pinang	26.493	0.009	0.167	0.234
Java	Jakarta	13.427	0.339	0.173	0.217
	Bogor	16.274	0.179	0.033	0.819
	Sukabumi	16.387	0.174	0.190	0.172
	Bandung	20.477	0.059	0.169	0.225
	Cirebon	23.456	0.024	0.256	0.070
	Bekasi	19.696	0.073	0.266	0.057
	Depok	22.656	0.031	0.219	0.123
	Tasikmalaya	21.434	0.044	0.125	0.379
	Cilacap	38.837	0.000	0.235	0.097
	Purwokerto	39.571	0.000	0.218	0.121
	Kudus	16.963	0.151	0.123	0.364
	Surakarta	26.828	0.008	0.245	0.076
	Semarang	23.584	0.023	0.163	0.248
	Tegal	31.764	0.002	0.174	0.221
	Yogyakarta	38.833	0.000	0.206	0.135
	Jember	18.906	0.091	0.252	0.065
	Banyuwangi	26.382	0.01	0.307	0.028
	Sumenep	28.445	0.005	0.261	0.063

Table 2.
Persistence of Cities' CPI Returns (Continued)

This table reports the persistency of *CPI* returns by way of the estimated first-order autoregressive, or AR(1), coefficient and the Ljung-Box *Q*-stat for serial correlation at lag 1–12.

Province/ Region	City	Ljung-Box test		AR(1)	
		<i>Q</i> -stat	<i>p</i> -value	Coef.	<i>p</i> -value
	Kediri	13.430	0.339	0.189	0.168
	Malang	21.849	0.039	0.267	0.057
	Probolinggo	30.623	0.002	0.221	0.111
	Madiun	18.236	0.109	0.266	0.056
	Surabaya	26.950	0.008	0.263	0.055
	Serang	17.815	0.121	0.248	0.076
	Tangerang	13.110	0.361	-0.098	0.491
	Cilegon	16.035	0.190	0.304	0.028
Bali & Nusa Tenggara	Singaraja	10.506	0.572	0.137	0.339
	Denpasar	27.476	0.007	0.365	0.006
	Mataram	46.085	0.000	0.269	0.047
	Bima	33.367	0.001	0.015	0.916
	Maumere	9.4810	0.661	0.063	0.663
	Kupang	63.387	0.000	0.296	0.035
Kalimantan	Pontianak	34.502	0.001	0.032	0.824
	Singkawang	45.872	0.000	0.225	0.101
	Sampit	52.395	0.000	0.329	0.016
	Palangkaraya	80.801	0.000	0.246	0.073
	Tanjung	27.618	0.006	0.172	0.194
	Banjarmasin	87.189	0.000	0.321	0.022
	Balikpapan	36.693	0.000	0.158	0.260
	Samarinda	51.588	0.000	0.258	0.057
	Tarakan	24.010	0.020	0.264	0.061
Sulawesi	Manado	6.487	0.890	-0.079	0.580
	Palu	41.871	0.000	0.004	0.977
	Bulukumba	22.071	0.037	0.184	0.190
	Watampone	14.167	0.290	0.036	0.802
	Makassar	15.815	0.200	0.119	0.398
	Pare-pare	53.812	0.000	0.272	0.055
	Palopo	27.943	0.006	0.032	0.813
	Kendari	21.780	0.04	0.205	0.150
	Bau-bau	30.515	0.002	0.025	0.856
	Gorontalo	24.767	0.016	-0.131	0.361
	Mamuju	54.407	0.000	0.141	0.325
Maluku-Papua	Ambon	6.136	0.909	0.107	0.457
	Tual	15.262	0.227	0.067	0.654
	Ternate	12.735	0.389	-0.159	0.267
	Manokwari	29.911	0.003	-0.038	0.791
	Sorong	48.474	0.000	0.257	0.068
	Merauke	23.209	0.026	0.288	0.037
	Jayapura	19.478	0.078	-0.194	0.166

The persistence of the *CPI* is also confirmed by the panel unit root test results reported in Table 3. The results show that the idiosyncratic component (from Equation (1)) turns out to be stationary. These unit root tests are consistent with the theoretical expectations of Equation (1) (WRN, 2017). These statistical features suggest the following: (1) city-level prices are different, so, when considered within a province, the most and least influential cities in shaping the aggregate *CPI* should become clear from our price discovery model. (2) City-based prices differ across provinces and, hence, provinces differ; therefore, we expect heterogeneity in terms of the number of cities that move prices the most within a province.

Table 3.
Unit Root Test

In this table we report the ADF and IPS unit root test results for the estimated common and idiosyncratic components, respectively. Both tests allow for a constant and a linear trend in the estimated model.

Province/Region	Component	Test	Value	p-value
Sumatera	Common	DF	-1.090	>0.10
	Idiosyncratic	IPS	-2.068	0.019
Java	Common	DF	-1.331	>0.10
	Idiosyncratic	IPS	-1.620	0.053
Bali & Nusa Tenggara	Common	DF	-1.306	>0.10
	Idiosyncratic	IPS	-2.087	0.018
Kalimantan	Common	DF	-1.753	>0.10
	Idiosyncratic	IPS	-2.101	0.018
Sulawesi	Common	DF	-1.316	>0.10
	Idiosyncratic	IPS	-1.773	0.038
Maluku-Papua	Common	DF	-1.759	>0.10
	Idiosyncratic	IPS	-2.459	0.007
31 top cities	Common	DF	-1.475	>0.10
	Idiosyncratic	IPS	-2.297	0.011

Table 4.
Price Discovery – By province/region

This table reports results from the price discovery test by province/region. The Information share is reported in column 2 and the factor loading is reported in column 3. The next three columns test the null hypothesis that the information share (price discovery) is equal to zero: the standard error (SE) of the test, its resulting *t*-statistic and *p*-values occupy these columns. The cities highlighted in red colours have the highest information shares in each province/region and their total PIS contribute more than 65% to each province/region *CPI*.

City	PIS	π	S.E	<i>t</i> -statistic	<i>p</i> -value
Panel A: Sumatera					
Lubuk Linggau	11.83%	1.046	0.063	16.690	0.000
Bungo	10.54%	0.867	0.086	10.122	0.000
Padang Sidempuan	8.58%	0.975	0.062	15.781	0.000
Tanjung Pinang	7.01%	0.779	0.088	8.898	0.000
Banda Aceh	6.12%	0.783	0.067	11.606	0.000
Lhokseumawe	6.09%	0.936	0.111	8.440	0.000
Bengkulu	5.97%	1.167	0.092	12.698	0.000
Tembilahan	5.36%	0.855	0.083	10.248	0.000

Table 4.
Price Discovery – By province/region (Continued)

This table reports results from the price discovery test by province/region. The Information share is reported in column 2 and the factor loading is reported in column 3. The next three columns test the null hypothesis that the information share (price discovery) is equal to zero: the standard error (SE) of the test, its resulting *t*-statistic and *p*-values occupy these columns. The cities highlighted in red colours have the highest information shares in each province/region and their total PIS contribute more than 65% to each province/region *CPI*.

City	PIS	π	S.E	<i>t</i> -statistic	<i>p</i> -value
Meulaboh	5.18%	0.808	0.089	9.114	0.000
Padang	3.80%	1.213	0.100	12.077	0.000
Pangkal Pinang	3.67%	1.202	0.174	6.896	0.000
Palembang	3.22%	0.837	0.063	13.289	0.000
Sibolga	3.10%	1.359	0.133	10.239	0.000
Batam	2.96%	0.930	0.075	12.378	0.000
Bukit Tinggi	2.82%	1.030	0.086	11.991	0.000
Medan	2.69%	1.002	0.084	11.871	0.000
Pematang Siantar	2.58%	0.898	0.092	9.783	0.000
Jambi	2.09%	1.087	0.083	13.109	0.000
Tanjung Pandan	1.88%	1.247	0.193	6.449	0.000
Pekanbaru	1.84%	0.850	0.071	11.893	0.000
Metro	1.13%	0.951	0.332	2.868	0.004
Bandar Lampung	1.05%	0.805	0.072	11.181	0.000
Dumai	0.50%	0.722	0.071	10.105	0.000
Panel B: Java					
Malang	16.17%	1.054	0.041	25.433	0.000
Sukabumi	12.14%	0.975	0.046	21.280	0.000
Cilacap	7.05%	1.072	0.063	17.137	0.000
Madiun	6.22%	0.958	0.038	25.526	0.000
Yogyakarta	5.04%	0.857	0.042	20.541	0.000
Semarang	4.83%	1.046	0.037	28.009	0.000
Kudus	4.82%	1.180	0.054	21.848	0.000
Sumenep	4.62%	0.978	0.044	22.043	0.000
Jakarta	4.19%	0.985	0.046	21.195	0.000
Bandung	3.39%	0.965	0.045	21.395	0.000
Depok	3.39%	1.016	0.046	21.925	0.000
Bekasi	3.21%	0.960	0.068	14.016	0.000
Cilegon	3.20%	1.253	0.091	13.762	0.000
Purwokerto	2.83%	0.999	0.050	20.096	0.000
Tegal	2.56%	0.952	0.061	15.510	0.000
Surabaya	2.21%	0.981	0.052	18.874	0.000
Tasikmalaya	2.20%	0.940	0.050	18.707	0.000
Cirebon	2.19%	0.793	0.062	12.852	0.000
Jember	1.77%	0.978	0.057	17.037	0.000
Probolinggo	1.76%	0.865	0.042	20.651	0.000
Banyuwangi	1.59%	0.893	0.052	17.290	0.000
Surakarta	1.43%	1.016	0.052	19.536	0.000
Serang	1.12%	1.170	0.131	8.906	0.000
Bogor	1.03%	0.927	0.069	13.362	0.000

Table 4.
Price Discovery – By province/region (Continued)

This table reports results from the price discovery test by province/region. The Information share is reported in column 2 and the factor loading is reported in column 3. The next three columns test the null hypothesis that the information share (price discovery) is equal to zero: the standard error (SE) of the test, its resulting *t*-statistic and *p*-values occupy these columns. The cities highlighted in red colours have the highest information shares in each province/region and their total PIS contribute more than 65% to each province/region CPI.

City	PIS	π	S.E	<i>t</i> -statistic	<i>p</i> -value
Kediri	0.76%	0.951	0.050	19.151	0.000
Tangerang	0.27%	0.993	0.202	4.929	0.000
Panel C: Bali & Nusa Tenggara					
Mataram	43.46%	0.867	0.076	11.377	0.000
Singaraja	17.43%	1.073	0.125	8.576	0.000
Bima	16.73%	0.925	0.117	7.892	0.000
Denpasar	10.97%	0.805	0.062	13.031	0.000
Maumere	6.02%	0.646	0.103	6.246	0.000
Kupang	5.39%	1.180	0.122	9.648	0.000
Panel D: Kalimantan					
Sampit	23.97%	0.918	0.072	12.722	0.000
Pontianak	18.06%	1.197	0.119	10.033	0.000
Palangkaraya	11.75%	0.784	0.072	10.919	0.000
Balikpapan	11.39%	1.063	0.092	11.571	0.000
Samarinda	11.18%	0.842	0.058	14.506	0.000
Tarakan	8.50%	1.074	0.093	11.527	0.000
Singkawang	7.13%	0.960	0.097	9.908	0.000
Tanjung	6.19%	0.993	0.107	9.263	0.000
Banjarmasin	1.82%	0.799	0.055	14.654	0.000
Panel E: Sulawesi					
Palu	19.58%	0.970	0.118	8.199	0.000
Palopo	17.01%	0.910	0.066	13.748	0.000
Gorontalo	16.07%	0.968	0.090	10.719	0.000
Manado	9.62%	1.016	0.132	7.710	0.000
Bulukumba	9.08%	0.963	0.073	13.205	0.000
Pare-pare	7.19%	1.022	0.073	13.981	0.000
Kendari	6.56%	1.051	0.097	10.816	0.000
Watampone	5.62%	0.826	0.071	11.672	0.000
Bau-bau	4.70%	1.152	0.146	7.879	0.000
Mamuju	2.85%	0.818	0.069	11.804	0.000
Makassar	1.71%	0.866	0.061	14.152	0.000
Panel F: Maluku-Papua					
Ternate	30.96%	0.826	0.141	5.875	0.000
Jayapura	19.28%	0.730	0.176	4.140	0.000
Ambon	13.44%	0.742	0.144	5.142	0.000
Tual	11.81%	1.236	0.280	4.420	0.000
Manokwari	11.52%	0.715	0.117	6.106	0.000
Merauke	10.01%	0.893	0.205	4.348	0.000
Sorong	2.98%	0.583	0.132	4.432	0.000

Figure 1.
Time Series CPI Index Returns

This figure plots the equally weight *CPI* returns for the top cities and non-top cities by province/ region over the sample period of January 2014 to April 2018.

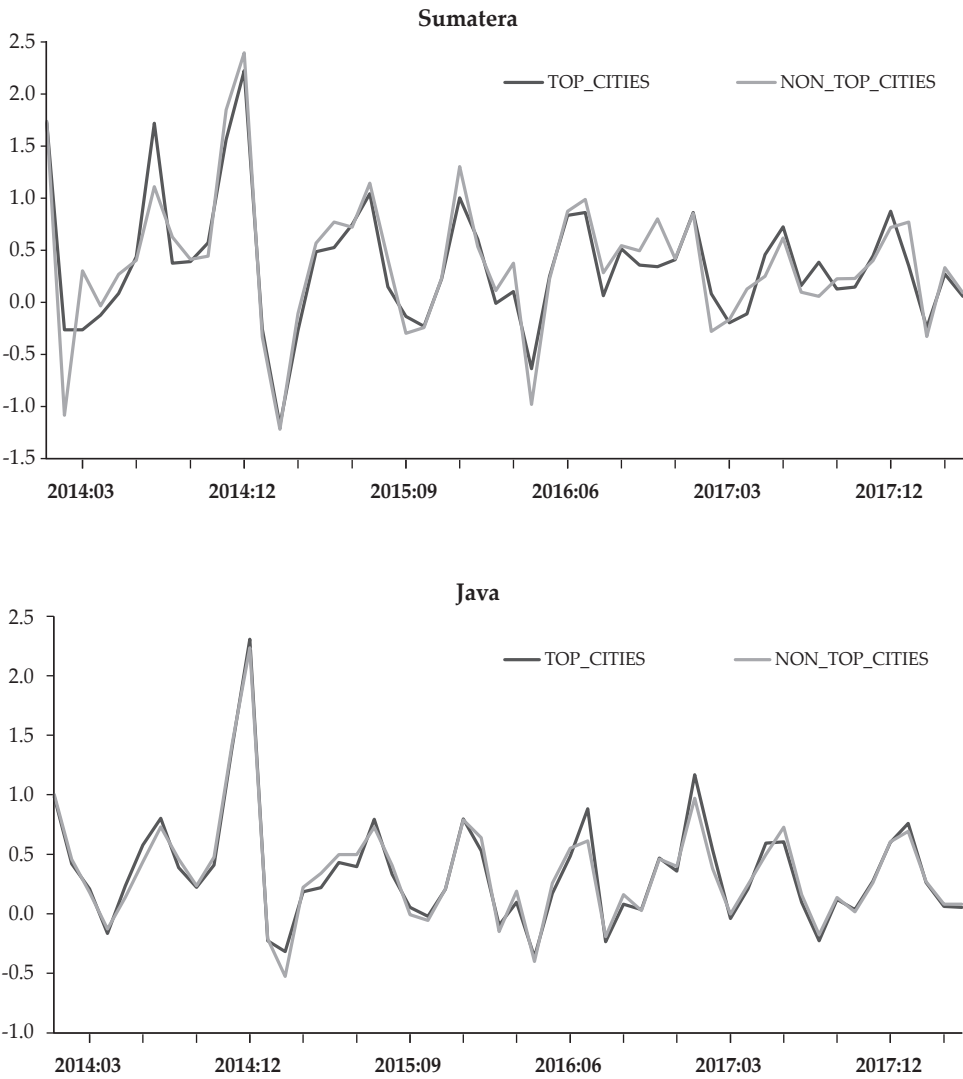


Figure 1.
Time Series CPI Index Returns (Continued)

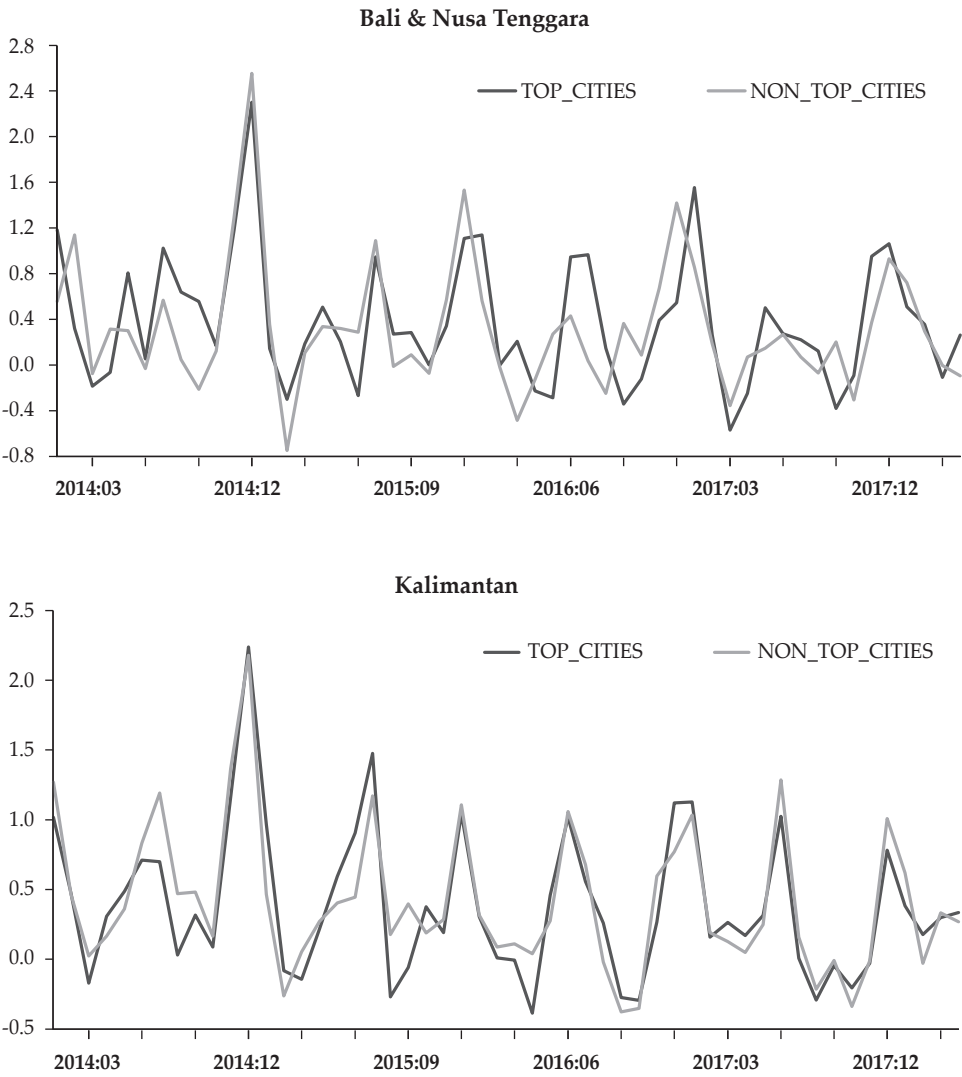
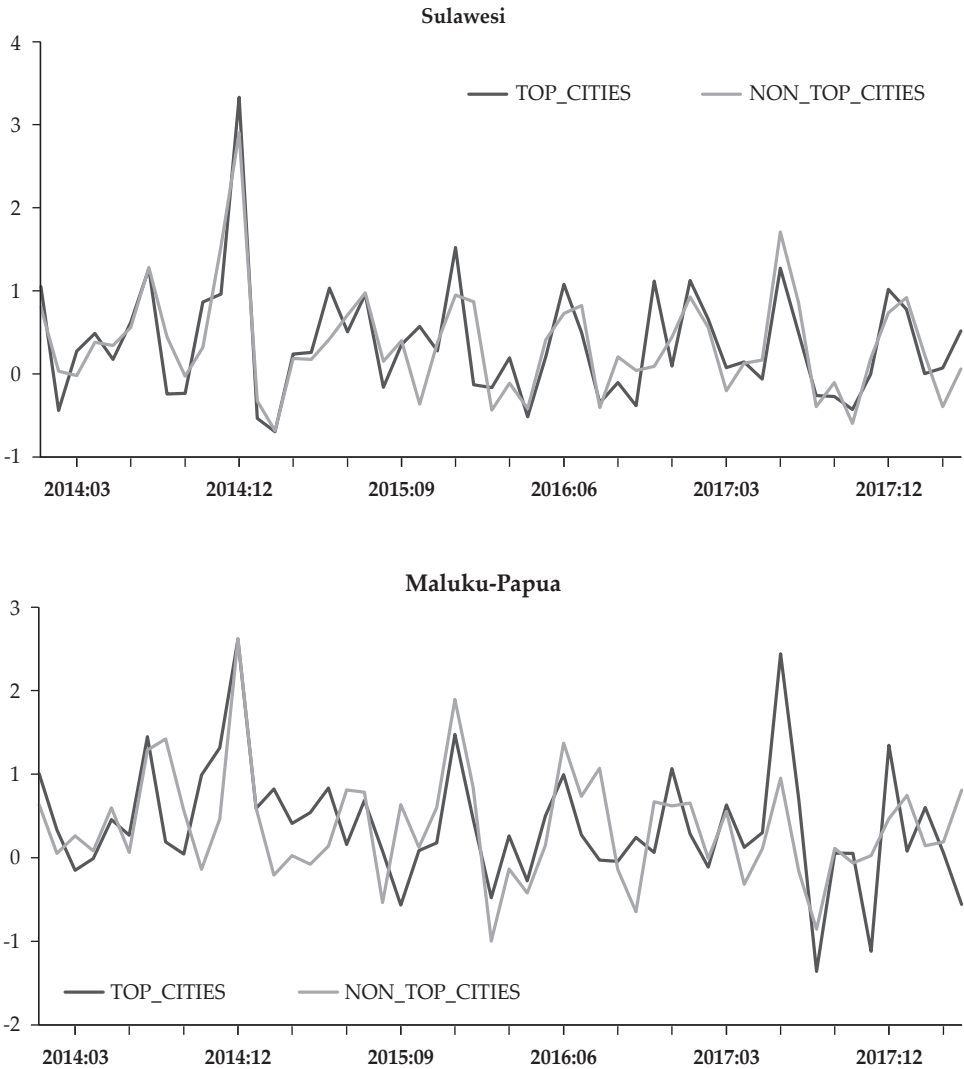


Figure 1.
Time Series CPI Index Returns (Continued)



We conclude with evidence of price discovery, that is, the relative importance of cities in the movement of prices in each of the six provinces. Of Sumatera's 23 cities, nine alone contribute 66.7% to the price changes, and five cities contribute 44% to all price changes. Similarly, among Java's 26 cities, nine contribute 65% to all price changes, with four contributing 41.6%. Even in smaller provinces, such as Bali and Nusa Tenggara, which have only five cities, one city alone contributes around 43% to all price changes. Across all six provinces, therefore, we identify a leader city and a group of cities that dominate the price changes. Our results imply that each province in Indonesia has between six and 26 cities, for a total of 82 cities. In controlling prices, given that the objective of Bank Indonesia, the central bank, is to maintain price stability, pricing-related policy should pay greater attention to the cities we identify as movers and shakers, or leaders.

To demonstrate their impact, we plot an equal-weighted price index for the leader cities against the other cities (Figure 1). The distinction between these two groups of cities in each province is obvious. This simple graphical analysis gives credence to our approach of searching for cities that contribute to price changes in a meaningful manner. The cost of not doing so is huge, because, from a policy point of view, the policy uncertainty resulting from not knowing which cities to target to control prices is not trivial. Our effort goes toward providing a guide to city selection when it comes to policymaking.

IV. CONCLUSIONS AND IMPLICATIONS

This paper aims to understand the CPI dynamics across Indonesian cities and provinces. A total of 82 cities belonging to six Indonesian provinces were analyzed to determine the leader cities, that is, those cities that contribute the most to the aggregate price changes for each province. Monthly time series data (2014M01 to 2018M04) were employed and the data fitted to a price discovery model that associates price changes with a common factor (i.e., the aggregate price change) and an idiosyncratic component of city price changes. A model based on the work of WRN paves the way for our empirical analysis. Simple characteristics of the CPI data for the sample of 82 cities indicate that city-based prices are heterogeneous across a range of statistical tests. This heterogeneity is reflected across provinces, suggesting that some cities move aggregate prices more than others. In formal price discovery tests, we observe precisely this: that each province contains cities that contribute more to prices changes and cities that contribute less. This finding has important implications for inflation policy.

The main takeaway from our paper is that it determines which cities to target if the objective is to control prices (or achieve price stability) in each province. Better price control in these leader cities will allow for faster convergence to price stability.

As a natural extension of our paper, future research can investigate why those cities appear as price leaders and why the other cities in each province do not contribute much to the aggregate price change. While answers to these questions will offer insights on the characteristics of cities about which we do not commentate in this paper, these answers though are independent of our policy recommendation.

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